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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	Confirmation No. 5549
Cheng *et al.*	Art Unit: 3629
Appl. No. 10/632,799	Examiner: *To be Assigned*
Filed: August 4, 2003	Atty. Docket: 2140.0020001/LEA/ALF
For: **Optimized Auction Commodity Distribution System, Method, and Computer Program Product**	

Declaration of Jie Cheng

Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

This declaration concerns certain activities related to the development of the present invention by Power Information Network, LLC ("PIN"), a division of J.D. Power & Associates ("JDPA"), that may be material to the examination of the above-captioned application. These facts are presented for consideration by the Examiner.

I, Jie Cheng, based on knowledge, information and/or belief, hereby declare:

1. I am an inventor of the invention described and claimed in the above-captioned United States patent application. I have been an employee of PIN from October 2000 to the present. From October 2000 to March 2004, I was employed as the Executive Director for Information Product Development. From March 2004 to the present, I have been employed as Vice President of Solution Development for the Power Information Network, LLC.

2. The following events occurred before February 14, 2002, which is one year prior to the filing date of U.S. Patent Application No. 10/366,719, filed February 14, 2003, to which the above referenced application claims priority.

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3. PIN is the assignee of the above captioned invention.

4. Prior to September 2001, a general genetic algorithm was developed. Although the application of the general algorithm for vehicle or other commodity remarketing applications was considered, any usefulness of the algorithm for commodity distribution would not be known until studies and testing using actual data from, for example, vehicle manufacturers were accomplished. Prior to September 2001, the genetic algorithm was used only on synthetic data generated at PIN, without implementing or incorporating real-world business constraints.

5. In September of 2001, I approached General Motors Corporation Remarketing ("GMC") regarding a feasibility study on the use of the proposed genetic algorithm. As shown in the proposal attached at Exhibit A, PIN initially asked GMC to pay the cost of development of the genetic algorithm application for use with actual historical data provided by GMC. However, the proposal attached at Exhibit A was not executed. The study proceeded using the historical actual data provided by GMC with PIN absorbing all costs of development. GMC did not pay any costs associated with the study.

6. GMC and JDPA have a history of jointly developing applications and conducting studies. As such, GMC was subject to any blanket confidentiality or non-disclosure agreements which existed between the two entities at the time of this September 2001 feasibility study.

7. During the study, the real nature of the data available from GMC was taken into consideration and coding changes in the application were made to account for the nature of the data and business constraints of GMC and the automobile industry in

general. For example, the algorithm was modified to take into consideration that certain shipping routes needed to be blocked, shipping time and consideration of elapsed time due to transportation as well as waiting time for auction sales, and finally, number of days needed for preparing the vehicles before they can be presented at auction sales, etc.

8. On January 11, 2002, I presented a Pilot Study Review for GMC, at which time GMC provided feedback regarding the pilot study. Attached at Exhibit B is the slide presentation prepared for the January 11, 2002 Pilot Study Review with GMC. From the collaboration with GMC, PIN learned about particular industry business constraints that must be considered and these business constraints were coded into the application.

9. Prior to September 2001, Automovia, a automobile auction company, knew generally that PIN had a genetic algorithm that might be useful in remarketing applications and was aware of the remarketing activities of DaimlerChrysler Fleet Remarketing (DCX). Thus, in September 2001, Automovia arranged a meeting between DCX and PIN.

10. At the time, I generally discussed the algorithm with DCX. DCX and PIN agreed to collaborate on a pilot study using historical data provided by DCX.

11. PIN bore all the costs of the DCX pilot study.

12. No formal written proposal or agreement existed between DCX and PIN.

13. On November 30, 2001, I presented the results of the pilot study to DCX, and DCX provided feedback regarding the pilot study. Attached at Exhibit C is the slide presentation that I presented on November 30, 2001. During the DCX pilot study, at least the following constraints were realized and coded into the application using the

genetic algorithm: maximum inventory volumes for specific sites; inventory volume target dates relative to sales dates, cost acceptance, limits on shipping certain vehicle types (colors, drivetypes, bodytypes) to certain sites at certain time of the year; and the temporary or permanent nature of these constraints.

14. The differences in the types and nature of data retained by automobile companies were acknowledged from both the GMC and DCX pilot studies. These differences were taken into consideration in universal coding changes to the application to make the application more useful to a broader range of commercial entities.

15. At the Institute For Operations Research and Management Sciences (INFORMS) Annual Conference, held November 2-3, 2001, I gave a presentation that included a general description of the algorithm used during the DCX pilot study. The presentation was directed to students and professors of combinatorial mathematics, but the conference was open to the public. The discussion was limited to the subject matter of the published abstract, which is attached hereto at Exhibit D. The slides presented at the conference are also attached hereto at Exhibit E. The slides were not published as a handout at the conference.

16. On January 11, 2002, I presented a second pilot study to DCX. A slide presentation of the proposal is attached at Exhibit F. The proposal includes a request from PIN that DCX pay the costs of $100,000 for conducting the pilot study. The proposal included several "challenges" or improvements to be made in the application during the collaborative study.

17. DCX did not agree to the second DCX pilot study. The second DCX pilot study did not take place.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements or the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the patent application or any patent issued thereon.

Jie Cheng

Date: 2/11/05

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A Proposal to General Motors Remarketing on a Pilot Study for the Optimal Distribution of Auction Vehicles

Background

A pilot study is proposed in this document in order to demonstrate the feasibility and benefits of applying JDPA/PIN's ODAV system (Optimal Distribution of Auction Vehicles) to GMC Remarketing's used vehicle auctions. This pilot study will also be an opportunity for GMC Remarketing and JDPA/PIN developers to identify areas where special customization is necessary.

Approach

We propose the following approach for the execution of this pilot study:

1. GMC Remarketing provides JDPA/PIN with auction related data for a past time period (one to two months). The data sets should include:
   - **Auction Price Prediction table** with rows for individual vehicles and columns for individual auction sites. The values in the table entries are the predicted gross auction proceeds for specific vehicles at specific auction sites.
   - **Shipping Cost Table** with rows representing marshalling yards or other possible sources for auction vehicles and columns for auction site destinations. The entries of this table are nominal charges for shipping a vehicle from specific source to specific destination locations.
   - **Shipping Time Table** with structures the same as that of Shipping Cost Table. The entries are number of days typically required to ship vehicles from specific source to specific destination locations.
   - **Time Value Table** which has rows for vehicle models and a single column for the typical daily inventory cost for a single vehicle of that vehicle model.
   - **Vehicle Depreciation Rate Table** which has rows for vehicle models and a single column for the current weekly depreciation of vehicle values for each model.
   - **Auction Inventory Table** which is dynamically adjusted to reflect the amount of supply for each vehicle model(row) at each auction site (column).
   - **Auction Site Capacity Constraint Table** which sets the limit on how many vehicles of a particular model are allowed for each possible auction site. An arbitrarily high number can be used to effectively remove such bounds.
   - **Local Demand Elasticity Table** which characterizes the impact of supply volumes on the auction prices. The rows are for vehicle models and columns are for auction sites. The value at each table entry represents auction price reductions per unit associated with a unit increase in auction volume for a specific model and auction site.
2. GMC Remarketing provides JDPA/PIN with a set of general business constraints or rules or guidelines on how the vehicles should or should not be distributed.
3. JDPA/PIN will take up to three weeks, after receiving all inputs from GMC Remarketign, to complete the pilot study. The efforts will include processing the input data, adjust the software and databases if needed, and running the program to

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obtain optimal distribution solutions relative to the given input and time frame. At the end of the study, JDPA/PIN will supply a comprehensive report documenting the optimization results, findings, and recommendations to GMC Remarketing. In addition, JDPA/PIN will provide a software demonstration to show both the ease-of-use and the efficiency of the program.

Project Timing and Costs

We estimate that the pilot study can be completed within three weeks after we receive from GMC Remarketing all the data sets as described before. This pilot study will cost $75,000 for all the software and database development efforts involved. This charge, however, will be completely credited towards the purchase of the entire project on the optimal distribution of GMC's auction vehicles.

Project Team and Key Contacts

Jie Cheng, Executive Director for Information Product Development, will manage the project and be the primary contact. Other people that will be involved include:

Jie Du, Senior Computer Scientist, Software Architect
Michael Jay, Marketing Science Project Director, Specialized in operations research
Wei Fan, Senior Econometrician, Software Developer
Keiko Powers, Senior Statistician
Yiem Sunbhanich, Econometrician
Computer Programmers

Power Information Network Proposal Acceptance

For J.D. Power and Associates

By:

_____

Scott Johnson

Title: Partner

Date: _____

For GMC Remarketing

By:

_____

Title: _____

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Optimal Distribution of Auction Vehicles (Pilot Study Review)

Presented to GMC Remarketing

January 11, 2002

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Outline

- JDPA's ODAV System
- Auction Distribution Optimization Pilot Study
  - Results Review
  - ODAV System Demonstration
- Discussion

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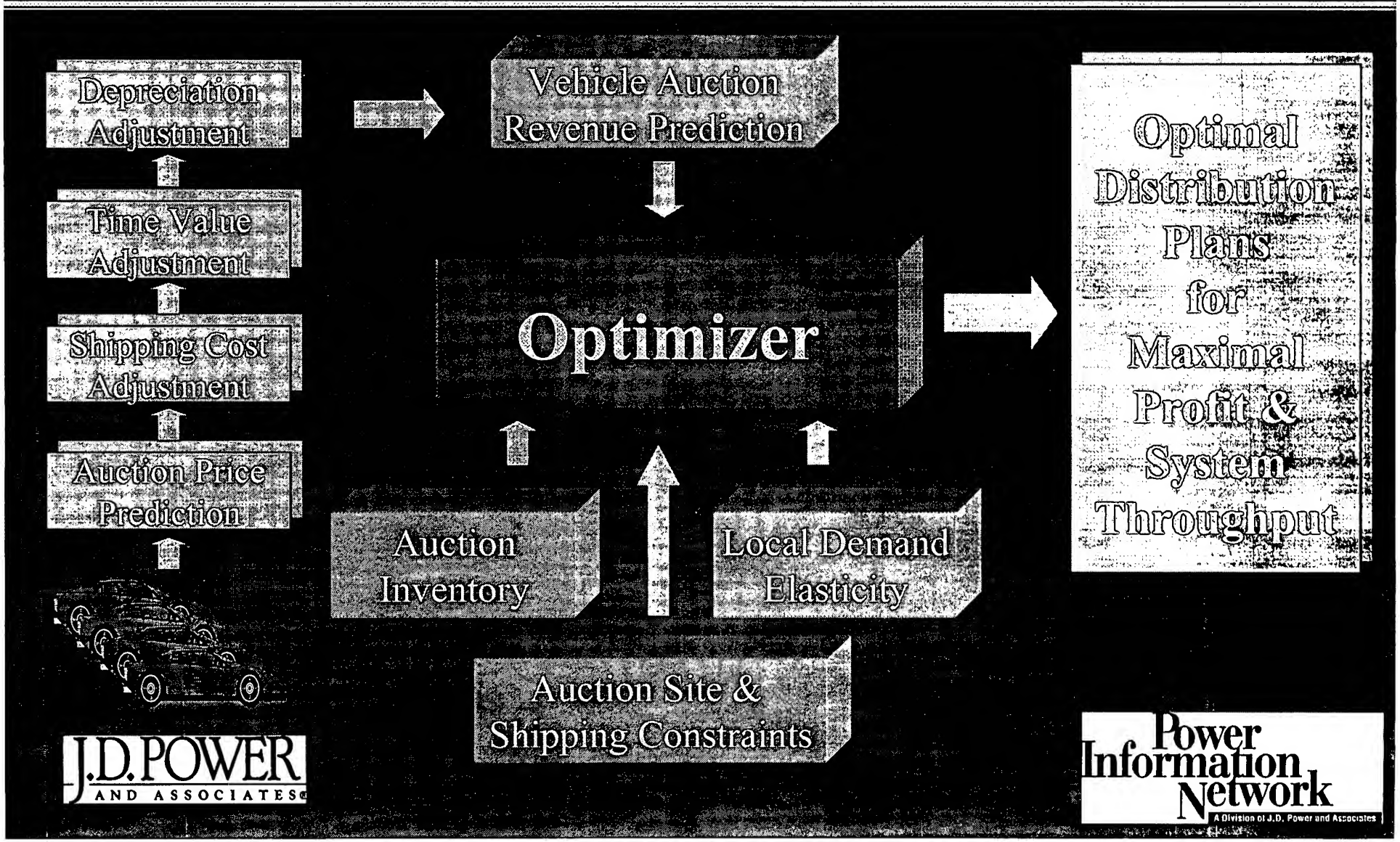
JDPA ODAV System Framework



ODAV System Description

- Written in C++
- GUI for Auction Operation Managers and Analysts
- ODBC Connections to External Databases
- Two Execution Modes
  - Auto-Pilot and Interactive
- Four Major Functions
  - Configuration Editor
  - Optimization Monitor
  - Auction Information Browser
  - Auction Reporting Tools

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GMC Auction Vehicle Distribution Pilot Study

Demonstration and Results

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Start Demonstration
(1st Day of Week 4)

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Pilot Test Data Sets

- Actual GMC auction data for April 2001
- Data Sets
  - Vehicle Shipping Schedule
  - Vehicle Floor Price by VIN by Auction Site
  - Marshalling Yard/Auction Site Definitions
  - Shipping Costs
  - Shipping Days (Estimated)
  - Inventory Interest Charge (Estimated)
  - Vehicle Depreciation (Not provided and not used in this study)
  - Local Demand Elasticity by Auction Site, Model, and Model Year
- Rules
  - Shipping Route Constraints (no shipping for certain routes)
  - Minimum shipment of 4 vehicles for each route

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Data Set Descriptions (1)

- Auction Vehicle Shipping Schedule
  - VIN, model, model year, originating marshalling yard, designated auction site, and shipping week
  - 55,180 vehicles provided; 36,953 actually used (67%)
    - Vehicles at turn-around sites were removed
    - Vehicles missing price information were removed
- Marshalling Yards
  - Label, address, map coordinates
  - 26 marshalling yards
- Auction Sites
  - Label, address, map coordinates
  - 55 auction sites

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Data Set Descriptions (2)

- Vehicle Floor Prices
  - Floor Prices by VIN by Auction Sites (37,000x55)
- Shipping Costs
  - The shipping costs by marshalling yard by auction site
  - Certain routes not permitted
- Shipping Days
  - Estimated # of days by marshalling yard by auction site
  - using 10 days for coast-to-coast shipping and estimate the rest by distance

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Data Set Description (3)

- Inventory Interest Charge
  - Daily interest rate charge by model and model year
  - Estimated using $5/day per vehicle on average and then scale with vehicle model average prices
- Vehicle Depreciation Costs
  - Not provided and assumed 0 for this pilot study

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Data Set Description (4)

- Local Volume Elasticity Estimation
  - Local volume elasticity is estimated for each auction site, and each model/model year combination
  - Currently using GMC's rule: 1% of price reduction for every 8% volume increase for every model/model year combination
  - This penalty was applied only when the local volume exceeds 100 vehicles

Pilot Test Results Review

- Remarketing profit improvement
  - for all four weeks
  - for each of the four weeks
  - for each of the five days in week 4
- Discussions
  - Optimization frequency tradeoffs
  - Next steps

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Remarketing Profit Improvement (All Four Weeks)

	All Vehicles			Per Vehicle			
	GM Profit($)	Opt. Profit($)	Diff ($)	# Vehicles	GM Profit ($)	Opt Profit ($)	Diff ($)
Week#1	116,717,906	128,338,274	11,620,368	10,455	11,164	12,275	1,111
Week#2	111,417,851	120,792,906	9,375,055	9,536	11,684	12,667	983
Week#3	90,245,786	98,679,748	8,433,962	7,799	11,571	12,653	1,081
Week#4	108,071,289	117,666,639	9,595,350	9,063	11,924	12,983	1,059
Total	**426,452,832**	**465,477,567**	**39,024,735**	**36,853**	**46,344**	**50,578**	**1,059**

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Remarketing Profit Improvement (Week 4)

	All Vehicles				
	Price($)	Shipping Cost($)	Interest($)	Vol. Elas. Cost($)	Profit($)
GM	109,656,500	1,430,784	140,647	13,669	108,071,289
Opt	120,256,700	2,347,818	213,275	28,708	117,666,639
Diff	10,600,200	917,034	72,628	15,039	9,595,350

	Per Vehicle				
	Price($)	Shipping Cost($)	Interest($)	Vol. Elas. Cost($)	Profit($)
GM	10,488	137	13	1	11,924
Opt	11,502	225	20	3	12,983
Diff	1,014	88	7	1	1,059

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Auction Performance Improvement (Contributions by Top 20 Mod/ModYear)

Rank	Mod/ModYr	Profit Gain ($)	% of Total Profit Gain	Cumulative % of Total Gain	VehNum	% of Total Volume	Cumulative % of Total Vol
1	2001/CHEVROLET BLAZER	581,026	6%	6%	354	4%	4%
2	1998/CADILLAC DEVILLE	496,420	5%	11%	204	2%	6%
3	2000/PONTIAC GRAND AM	495,595	5%	16%	963	11%	17%
4	2000/CHEVROLET MALIBU	413,625	4%	21%	605	7%	23%
5	2000/OLDSMOBILE ALERO	402,136	4%	25%	601	7%	30%
6	2000/CHEVROLET CAVALIER	369,097	4%	29%	511	6%	36%
7	1998/CHEVROLET S10	367,862	4%	33%	285	3%	39%
8	1998/CHEVROLET BLAZER	292,508	3%	36%	180	2%	41%
9	2000/BUICK CENTURY	291,603	3%	39%	406	4%	45%
10	2000/PONTIAC SUNFIRE	271,276	3%	41%	281	3%	48%
11	1999/CHEVROLET TAHOE	260,989	3%	44%	51	1%	49%
12	2001/GMC JIMMY	249,647	3%	47%	156	2%	51%
13	2000/CHEVROLET BLAZER	231,259	2%	49%	164	2%	53%
14	1999/CADILLAC DEVILLE	211,331	2%	51%	112	1%	54%
15	2000/CHEVROLET LUMINA	195,601	2%	53%	278	3%	57%
16	2000/OLDSMOBILE INTRIGUE	189,615	2%	55%	193	2%	59%
17	2000/CHEVROLET ASTRO VANS	186,422	2%	57%	107	1%	60%
18	2000/PONTIAC GRAND PRIX	168,404	2%	59%	199	2%	62%
19	2000/CHEVROLET PRIZM	165,787	2%	61%	198	2%	65%
20	2001/BUICK LESABRE	156,162	2%	62%	126	1%	66%

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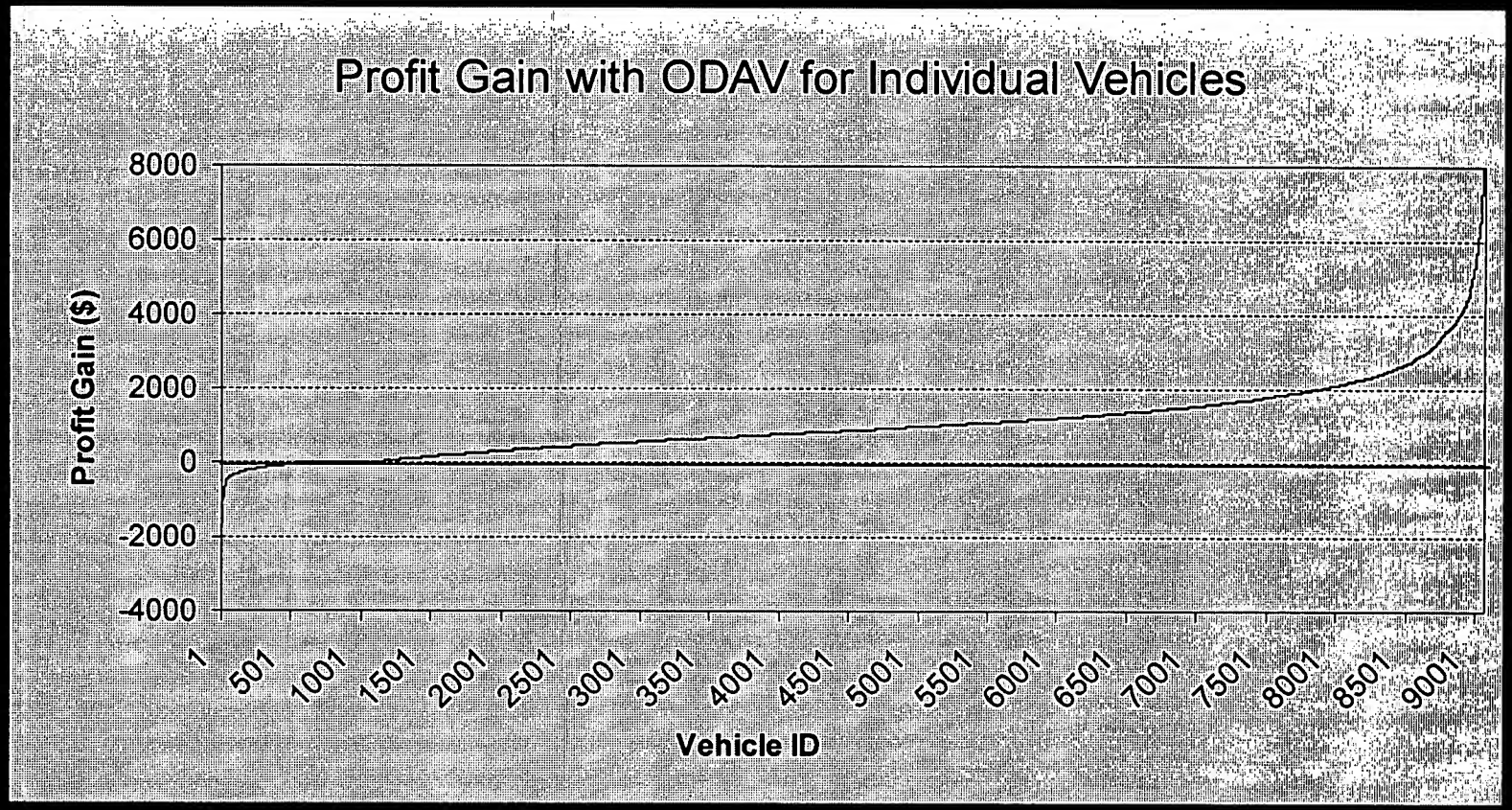
Auction Performance Improvement



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Auction Performance Improvement (Daily Auction Optimization for Week 4)

	Daily Optimization Results for Week 4					
	Revenue	Shipping Cost	Time Cost	Elasticity Cost	Profit	VehNum
Day1	24,111,000	485,433	43,704	0	23,581,863	1,813
Day2	24,130,200	482,647	43,407	5,413	23,598,706	1,813
Dya3	23,978,600	475,443	42,592	44,018	23,416,514	1,813
Day4	24,128,900	465,168	42,631	83,590	23,537,502	1,812
Dya5	24,057,200	464,070	42,159	131,818	23,419,114	1,812
Total	120,405,900	2,372,761	214,493	131,818	117,686,720	9,063
Weekly	121,110,900	2,276,388	208,712	16,285	118,609,154	9,063

Based on the assumption that all previous days' units are still in inventory

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Summary

- **Business Impact**
  - The pilot study demonstrates there exists GREAT opportunity for the further improvement of GMC remarketing profits
- **Capability**
  - In addition to optimization, ODAV system can be used to visualize auction market at many different detail levels, to help track shipping and inventory changes, and to assist in developing and evaluating alternative auction strategies
- **Efficiency**
  - ODAV can be run efficiently on a PC on a daily basis
- **Flexibility**
  - ODAV is very flexible and can accept many types of business constraints through the graphical user interface

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Discussion

- Optimization Frequency
  - Multiple runs daily
  - Single run per day
  - Single run per week
- Next Steps

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Optimal Distribution of Auction Vehicles

Presented to DCX Remarketing

November 30, 2001

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Outline

- JDPA Optimal Distribution of Auction Vehicles
- Evolutionary Computation Technology
- JDPA Auction Price Prediction System

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Importance of Improving Vehicle Distribution

√ Throughput

- Reduction of one single day on average from vehicle return to auction disposal

$$\$5 \times 250{,}000 = \$1{,}250{,}000$$

√ Resale Value

- Increase of auction price by a single bid ($100) on average with optimal site allocations

$$\$100 \times 250{,}000 = \$25{,}000{,}000$$

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JDPA ODAV Solution

- JDPA can provide DCX with the best solution for the Optimal Distribution of Auction Vehicles
  - Most advanced computational technology for optimizing large and complex systems or operations
  - Accurate and flexible auction price prediction models
  - A strong development team with specialists in Operations Research, Econometric and Statistical Data Analysis, Computer programming, and Information Systems
  - Many years of experience in applying computational technologies to vehicle remarketing business applications
  - Software system can be easily tailored to the needs, priorities, and constraints of the DCX remarketing business

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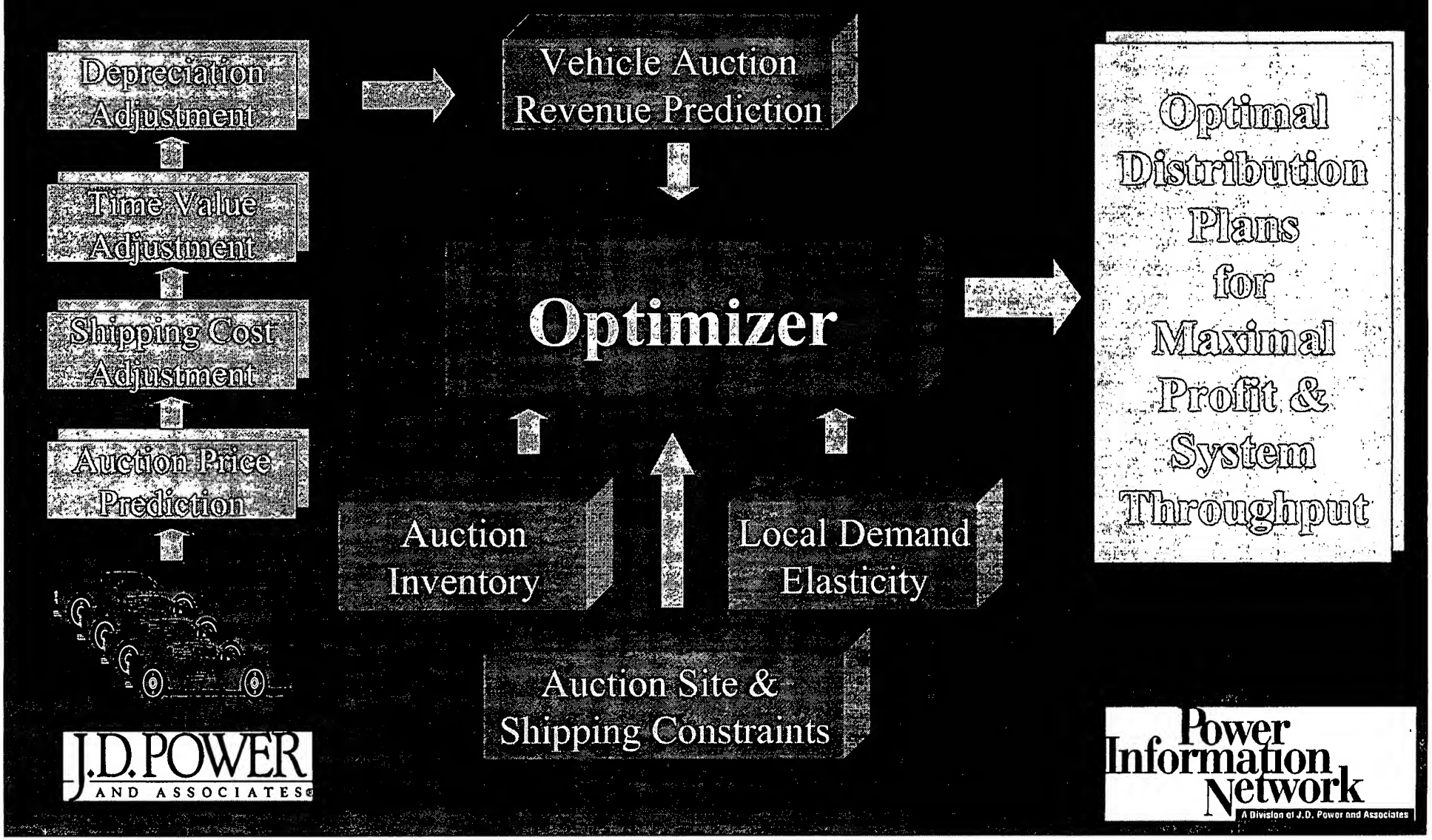
JDPA ODAV System Framework



Auction Price Prediction

- Predict the most likely gross auction proceeds for each individual vehicle at each alternative auction site

	Site #1	Site #2	Site #3	...	...	...	Site #N
Veh #1	$10,900	$11,273.23	$9,734.41	...	...	...	$10,972.74
Veh #2	$10,805	$9,875.20	$8,077.39	...	...	...	$10,828.60
Veh #3	$9,827	$10,679.54	$6,485.12	...	...	...	$13,485.32
Veh #4	$12,368	$15,196.39	$16,097.55	...	...	...	$8,836.70
Veh #5	$13,521	$15,334.79	$15,268.98	...	...	...	$11,649.50
Veh #6	$7,342	$4,860.51	$6,203.87	...	...	...	$5,858.03
Veh #7	$2,050	$1,754.86	$2,419.00	...	...	...	$2,019.07
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Veh #M	$9,809	$13,446.37	$9,791.94	...	...	...	$11,116.10

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Shipping Cost Adjustment

- Deduct shipping cost from the gross auction proceeds of each individual auction vehicle
- Shipping cost amount depends on the originating Marshalling Yard and the auction site destination

	Site #1	Site #2	Site #3	...	...	...	Site #N
M. Yard #1	$150	$150.00	$250.00	...	...	...	$150.00
M. Yard #2	$150	$150.00	$500.00	...	...	...	$200.00
M. Yard #3	$200	$200.00	$250.00	...	...	...	$150.00
M. Yard #4	$250	$200.00	$250.00	...	...	...	$200.00
M. Yard #5	$150	$100.00	$50.00	...	...	...	$250.00
M. Yard #6	$150	$150.00	$100.00	...	...	...	$250.00
M. Yard #7	$100	$100.00	$150.00	...	...	...	$150.00
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
M. Yard#M	$200	$150.00	$200.00	...	...	...	$150.00

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Time Value Adjustment

- Deduct estimated value lost due to interest cost for the time spent in vehicle shipping

	Site #1	Site #2	Site #3	...	...	...	Site #N
M. Yard #1	10	5	5				4
M. Yard #2	10	20	15				3
M. Yard #3	14	25	15				3
M. Yard #4	3	5	20				10
M. Yard #5	5	10	20				10
M. Yard #6	10	15	10				12
M. Yard #7	10	10	15				3
...							
...							
...							
M. Yard #M	15	20	10				4

Shipping Time Table (Days)

	Interest Costs Per Day
Vehicle Model #1	$5.00
Vehicle Model #2	$15.00
Vehicle Model #3	$7.00
Vehicle Model #4	$10.00
Vehicle Model #5	$10.00
Vehicle Model #6	$12.00
Vehicle Model #7	$10.00
...	
...	
...	
Vehicle Model #M	$8.00

Time Value Table

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Vehicle Depreciation Adjustment

- Vehicle depreciation rate is a function of vehicle age as well as seasons in a year
- Timing of auctions needs to consider trade-off between resale value gains and possible depreciation losses

	Weekly Depreciation Rate
Vehicle Model #1	$300
Vehicle Model #2	$500
Vehicle Model #3	$200
…	…
…	…
…	…
Vehicle Model #K	$350

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Auction Inventory

- Levels of auction inventory can have an effect on gross auction proceeds and are constrained by auction site capacity

	Site #1	Site #2	Site #3	...	...	...	Site #N
Veh Model #1	53	23	67	...	...	...	91
Veh Model #2	68	18	62	...	...	...	2
Veh Model #3	72	74	56	...	...	...	40
Veh Model #4	6	75	38	...	...	...	79
Veh Model #5	31	16	18	...	...	...	64
Veh Model #6	86	84	78	...	...	...	27
Veh Model #7	53	82	49	...	...	...	58
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Veh Model #K	67	77	88	...	...	...	40

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Auction Site Capacity Constraints

- For each auction site, there are both a limit on the number of vehicles of a particular type and a limit on the total number of vehicles

	Site #1	Site #2	Site #3	...	...	...	Site #N
Vehicle Model #1	100	200	50	...	...	...	100
Vehicle Model #2	100	250	100	...	...	...	100
Vehicle Model #3	100	100	100	...	...	...	150
Vehicle Model #4	50	100	75	...	...	...	200
Vehicle Model #5	100	50	100	...	...	...	150
Vehicle Model #6	300	100	150	...	...	...	50
Vehicle Model #7	100	100	100	...	...	...	100
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Vehicle Model #M	200	60	100	...	...	...	50
Total	500	650	400	...	...	...	350

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Local Demand Elasticity

- Local demand elasticity refers to the sensitivity of auction prices in response to volume fluctuations

	Site #1	Site #2	Site #3	...	...	...	Site #N
Vehicle Model #1	-$0.20	-$0.20	-$0.10	...	...	...	-$0.20
Vehicle Model #2	-$0.10	-$0.20	-$0.15	...	...	...	-$0.10
Vehicle Model #3	-$0.10	-$0.15	-$0.15	...	...	...	-$0.20
Vehicle Model #4	-$0.15	-$0.20	-$0.10	...	...	...	-$0.15
Vehicle Model #5	-$0.20	-$0.20	-$0.10	...	...	...	-$0.10
Vehicle Model #6	-$0.20	-$0.15	-$0.15	...	...	...	-$0.20
Vehicle Model #7	-$0.15	-$0.10	-$0.20	...	...	...	-$0.15
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Vehicle Model #M	-$0.20	-$0.10	-$0.30	...	...	...	-$0.10

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System Output: Optimal Distribution Plans

- Solutions are ranked by net proceeds (= estimated gross auction proceeds - shipping costs - time_value_lost - depreciation) *

	Site	Gross Proceeds	Shipping Cost	Time-Cost	Net Proceeds	Est. Auc. Date
Vehicle #1	1	$12,450.00	$250.00	$100.00	$12,100.00	07/30/01
Vehicle #2	2	$8,000.00	$100.00	$10.00	$7,890.00	07/30/01
Vehicle #3	1	$9,570.00	$150.00	$10.00	$9,410.00	08/07/01
Vehicle #4	4	$11,590.00	$220.00	$50.00	$11,320.00	08/07/01
Vehicle #5	20	$3,925.00	$140.00	$10.00	$3,775.00	08/09/01
Vehicle #6	2	$4,750.00	$100.00	$100.00	$4,550.00	08/02/01
Vehicle #7	3	$12,120.00	$100.00	$50.00	$11,970.00	08/02/01
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
Vehicle #M	41	$13,120.00	$100.00	$100.00	$12,920.00	08/02/01

* Auction cost is almost constant and excluded here

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Auction Vehicle Distribution Optimizer

- Seeking the determination of a maximum net revenue transportation plan for multiple types of vehicles from a number of sources (marshalling yards) to a number of destinations (auction sites)
- A non-linear combinatorial decision problem
  - Non-linear: both objective function and constraints are non-linear with respect to the number of vehicles to be transported
  - Combinatorial: For a total of M vehicles, each vehicle can have N alternative destinations, therefore the decision space size is N^M (for M=1000, N=30, search space size = $1000^{30} \sim 10^{90}$)

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Optimization Constraints

- Vehicles of certain type(s) originating from certain marshalling yard(s) must be (or must not be) shipped to certain site(s)
- Vehicle inventory volume for a particular type of vehicle should not exceed a certain level for a specific site
- Vehicles with certain equipment (such as 4x2, 4x4) or features (colors) should only be shipped to certain sites
- These constraints can be set up as temporary (such as one time only) or permanent (good until cancelled)

Evolutionary Computation(EC) Technology

- EC encompasses methods of simulating nature's evolution processes on a computer
- EC enables a scalable solution to large and complex real world optimization problems
- Advantages: broad applicability, adaptive to changing circumstance, and flexibility in incorporating domain knowledge
- Many successful industrial applications in the optimization of engineering designs and logistic operations

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ODAV Software SYSTEM

- Written in C++
- GUI for Auction Operation Managers and Analysts
- ODBC Connections to External Databases
- Two Execution Modes
  - Auto-Pilot and Interactive
- Four Major Functions
  - Configuration
  - Optimization Monitor
  - Auction Information Browse
  - Optimization Report

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Auction Price Prediction

- Auction price prediction is a key module for the optimal distribution of auction vehicles
- JDPA has developed an auction vehicle pricing system with leading edge technologies enhanced by its unique PIN retail transaction databases
- This system provides vehicle specific valuations based on market conditions, seasons, regions, feature contents, mileage, and auction types
- The JDPA auction vehicle pricing system has been proven in applications to be much more accurate, robust, and flexible than traditional approaches

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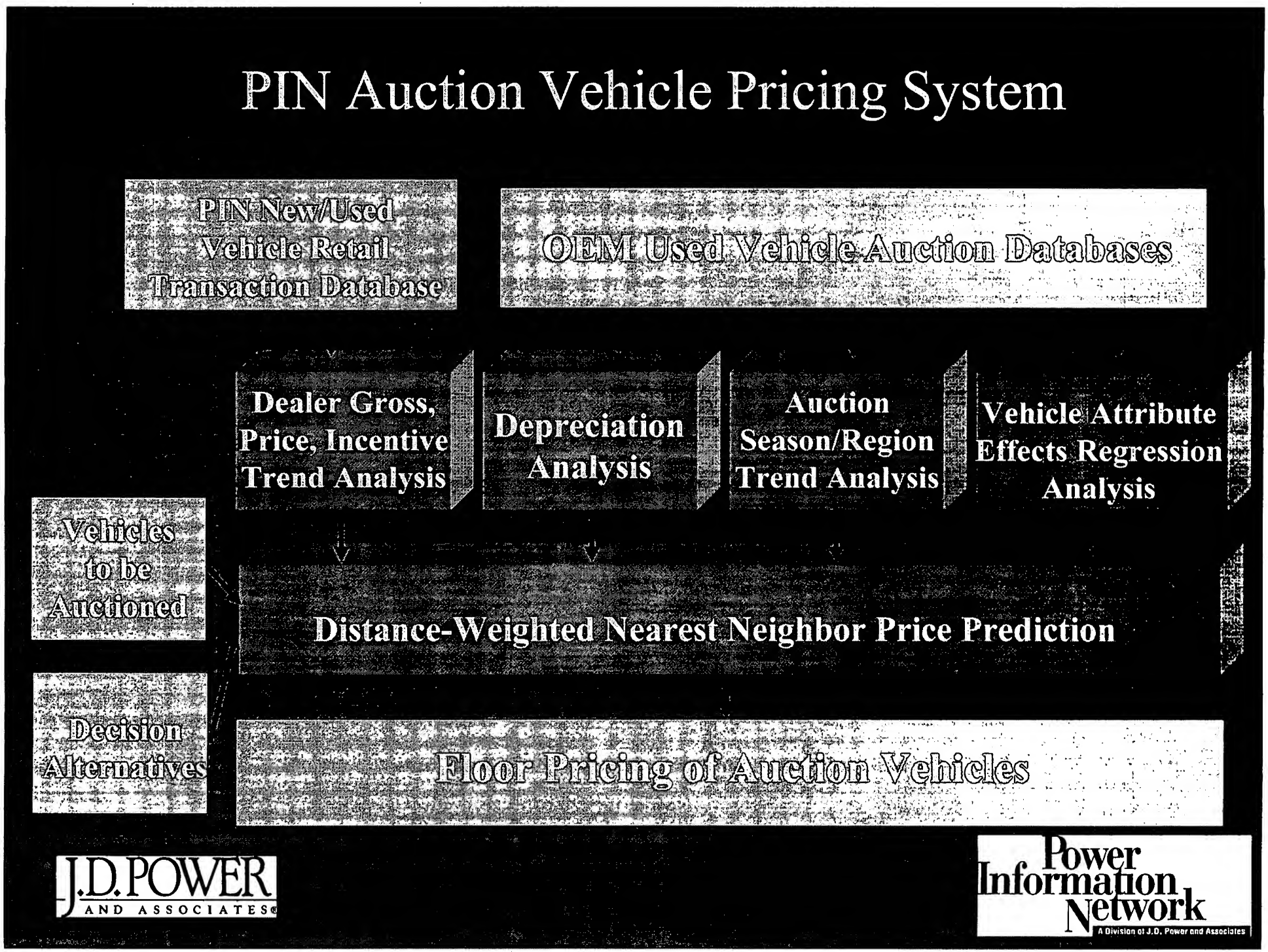
PIN Auction Vehicle Pricing System



Vehicle/Auction Attributes Analysis

- Vehicle age (months) starting from Jan. in the vehicle's model year
- Mileage and Mileage per Month (MPM) band
- Auction Month
- Auction Region or State
- Trim Level/Series
- Optional Equipment (Drive, Doors, Wheel, A/C, Sound system, ...)
- Exterior/Interior Paint Colors
- Vehicle Conditions
- Auction Type (Open/Closed)
- Auction Volume (to be used in modeling local demand elasticity)

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DCX Auction Vehicle Distribution Pilot Study

Demonstration and Results

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DCX Pilot Study Auction Vehicle Data Set

- 1295 vehicles (2001MY)
- 29 Originating Marshalling Yards
- 43 Auction Sites
- Predicted Auction Prices (for all vehicles and all auction sites)
- Shipping Costs/Time (for all marshalling yards and all auction sites)
- Asset Interest Rates ($5/day/vehicle, per DCX's suggestion)
- Weekly Depreciation ($35/week, per DCX's suggestion)
- Local Volume Elasticity ($5/vehicle after inventory exceeds 10 for a specific vehicle model/model year/trim combination)
- Shipping Constraints
  - Connectivity between marshalling yards and auction sites
  - Trucking capacity should be fully utilized

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Auction Performance Improvement

	Original ($)	Optimal ($)	Change ($)
Profit	19,242,808	19,614,939	372,131
Auction Revenue	19,508,156	20,039,525	531,369
Shipping Cost	(180,960)	(346,936)	(165,976)
Time Value Cost	(25,158)	(34,020)	(8,862)
Volume Elasticity Cost	(59,230)	(43,630)	15,600
Shipping Waste Cost	(49,013)	(55,658)	(6,645)

- Constraints imposed so that vehicles shipped are to be closest possible to the multiple of eight.
- Computer Time for a Complete Optimization Run:
  < 5 min. on a Sony PCG-FXA36 laptop

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Auction Performance Improvement (Per Vehicle)

	Original ($)	Optimal ($)	Change ($)
Profit	15,272	15,567	295
Auction Revenue	15,483	15,904	422
Shipping Cost	(144)	(275)	(132)
Time Value Cost	(20)	(27)	(7)
Volume Elasticity Cost	(47)	(35)	12
Shipping Waste Cost	(39)	(44)	(5)

Number of vehicles: 1,260 (36 vehicles removed due to lack of information)

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Auction Performance Improvement (Shipment Size Constraint Removed)

	Original ($)	Optimal ($)	Change ($)
Profit	19,291,821	19,716,031	424,210
Auction Revenue	19,508,156	20,016,247	508,091
Shipping Cost	(131,947)	(213,367)	(81,420)
Time Value Cost	(25,158)	(29,769)	(4,611)
Volume Elasticity Cost	(59,230)	(57,080)	2,150
Shipping Waste Cost	-	-	-

- Constraints imposed so that vehicles shipped are to be closest possible to the multiple of eight.
- Computer Time for a Complete Optimization Run:
  < 5 min. on a Sony PCG-FXA36 laptop

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Auction Performance Improvement (Per Vehicle, Shipment Constraint Removed)

	Original ($)	Optimal ($)	Change ($)
Profit	15,311	15,648	337
Auction Revenue	15,483	15,886	403
Shipping Cost	(105)	(169)	(65)
Time Value Cost	(20)	(24)	(4)
Volume Elasticity Cost	(47)	(45)	2
Shipping Waste Cost	-	-	-

Number of vehicles: 1260 (36 vehicles removed due to lack of information)

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Original Auction Vehicle Distribution Plan

	500	501	503	506	508	509	529	530	532	533	535	537	538	539	540	550	553	554	556	557	558	561	586	590	593	594	595	597	598
VR101		33	8	53				25														2							
VR104					13			7				8				1		2				5							
VR107												1						23				1	2			112		82	
VR108							1						13					3	11	1			38			24			
VR110									1																				
VR112										18																			
VR113							58	1																					
VR114																													42
VR115																									23				
VR116																		2									15		
VR117			59																										
VR118					16																								
VR119											25																		
VR120																													
VR121																9													
VR122																		52											
VR123																			6										
VR124		8										17	6						27	153									
VR125													1											50					
VR126																										23			
VR130				93																									
VR131																													
VR132													10																
VR133																						4							
VR134																	54												
VR135	5																												
VR136						13																							
	5	41	67	146	29	13	59	33	1	18	25	26	30	0	0	10	54	82	44	154	0	12	40	50	23	159	15	82	42

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Optimized Auction Vehicle Distribution Plan

	500	501	503	506	508	509	529	530	532	533	535	537	538	539	540	550	553	554	556	557	558	561	586	590	593	594	595	597	598
VR101	16	11	16	30	14	5	2					8					4	8		3		4							
VR104		2		5				3				12	7					7											
VR107	8	8	24			7				7							6	16	8			8	32	3	32	24	8	23	7
VR108		4	7				5			7		7			8			8				8	10			7	8	4	8
VR110									1																				
VR112										8		7	3																
VR113	8				3	4	14											8	8	8		8							
VR114		3											8									8	3				8		12
VR115																									15		8		
VR116										5					3			6									3		
VR117	16	3	17	7	16																								
VR118			6		10																								
VR119			3		8			8			1								5										
VR120																													
VR121			3														8												
VR122																		52											
VR123																			6										
VR124	8	4			8	8	16	2		8		8	8		8		11	22	40	40		16					8		
VR125																		6					7	1	16		16		5
VR126																	8					4				7	4		
VR130	3	14	8	30	24												6	8											
VR131																													
VR132					10																								
VR133																						4							
VR134																	54												
VR135	5																												
VR136	5					1														2		5							
	69	49	84	72	93	25	37	13	1	35	1	42	24	0	19	0	95	141	67	51	0	65	52	4	63	38	61	27	32

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Optimal Distribution of Auction Vehicles with an Evolutionary Algorithm

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- Jie Cheng; JD Power & Associates, 5435 Corporate Dr., Ste. 300, Troy, MI 48098; jie.cheng@jdpa.com
- Wei Fan; JD Power & Associates, 5435 Corporate Dr., Ste. 300, Troy, MI 48098; wei.fan@jdpa.com

A system has been developed for the optimal allocation of auction vehicles to maximize net remarketing profit for automotive manufacturers. The system is based on an evolutionary algorithm by representing the problem as an evolution of solution populations. The optimization is achieved through successive applications of genetic operators and selections of the best performing solutions.

Optimal Distribution of Auction Vehicles with Evolutionary Algorithm

Jie Du, Jie Cheng, and Wei Fan

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Outline

- Background
- Implementation
- Results
- Summary

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Background

- 300 ~ 3000 vehicles distributed per week for auction
- Distributed from ~30 marshalling yards to ~40 auction sites nationwide
- Wide range of prices due to mixed models, model years, vehicle attributes, conditions, and auction site locations
- Auction price variations due to constantly changing national and local market conditions
- Vehicle depreciation and interest rate cost
- Various constraints on shipments and auction site capacities

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Objective

- Profit maximization where

PROFIT = f(auction revenue,
shipping cost,
inventory charge,
local volume elasticity)

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Why Evolutionary Algorithm

- Large search space (M^N)
- Non-linear complex objective function
- Variety of constraints
- Rugged solution landscape due to certain constraints

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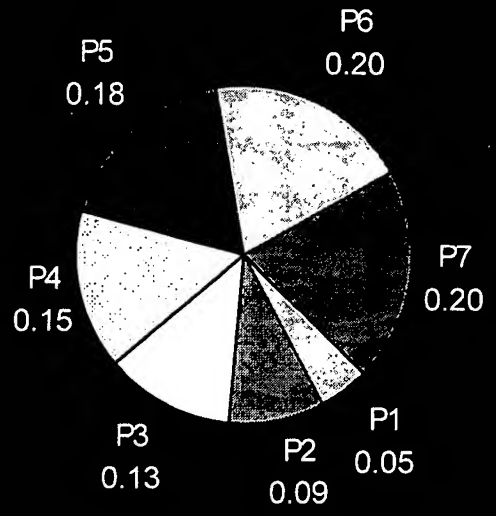
Problem Representation

- Genome: an array of vehicle class
  - The size of array is the number of vehicles to be auctioned
  - The genetic operators: altering the auction site of a gene
- Gene: a vehicle class
  - Vehicle specifications
  - The marshalling yard it originates from
  - An auction site it will be shipped to
- Population: a collection of genomes
  - The size of the population is user defined

Genetic Operators

- Selection
  - Randomly generates a new generation based on the fitness of the their parents



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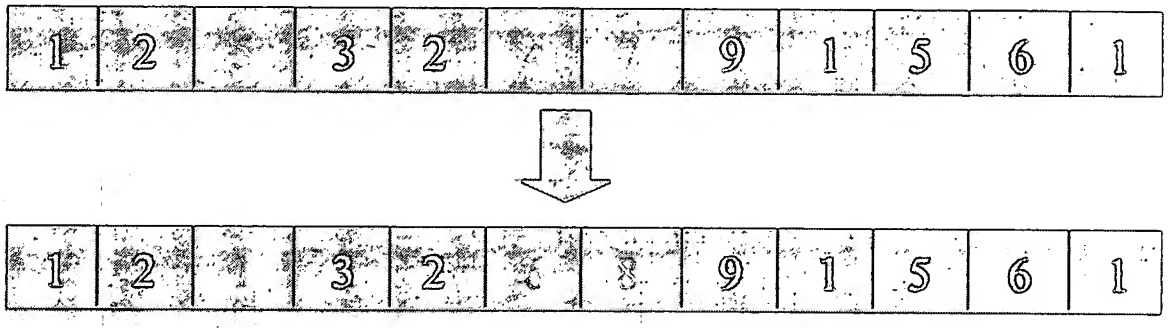
Genetic Operators

- Mutation
  - Randomly selects N_m genes from a genome
  - Randomly assigns new auction sites to the N_m genes



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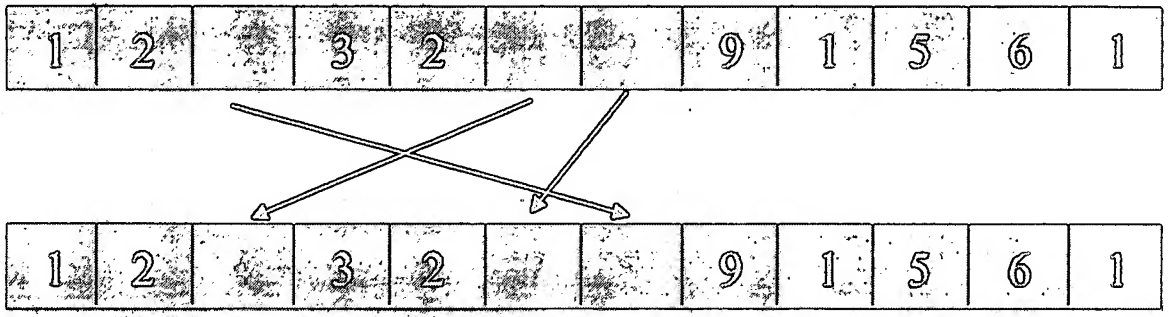
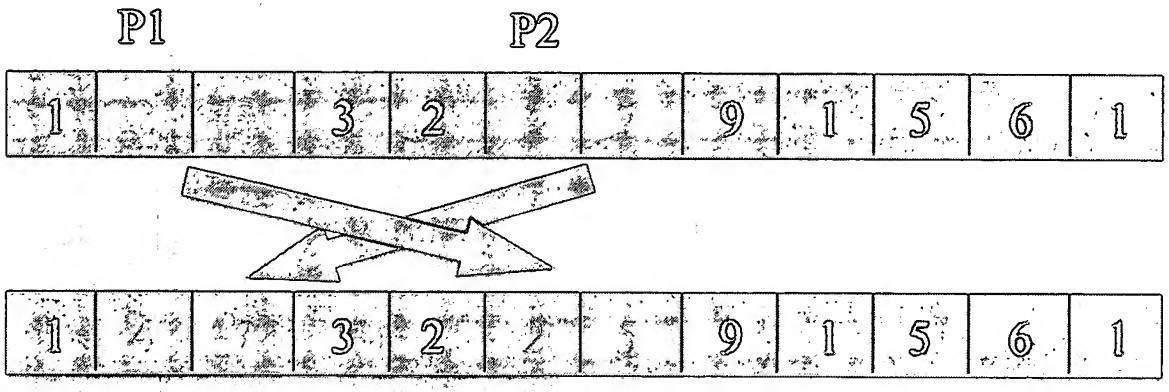
Genetic Operators

- Switch
  - Randomly selects N_s genes from a genome
  - Randomly generates permutation of their auction sites



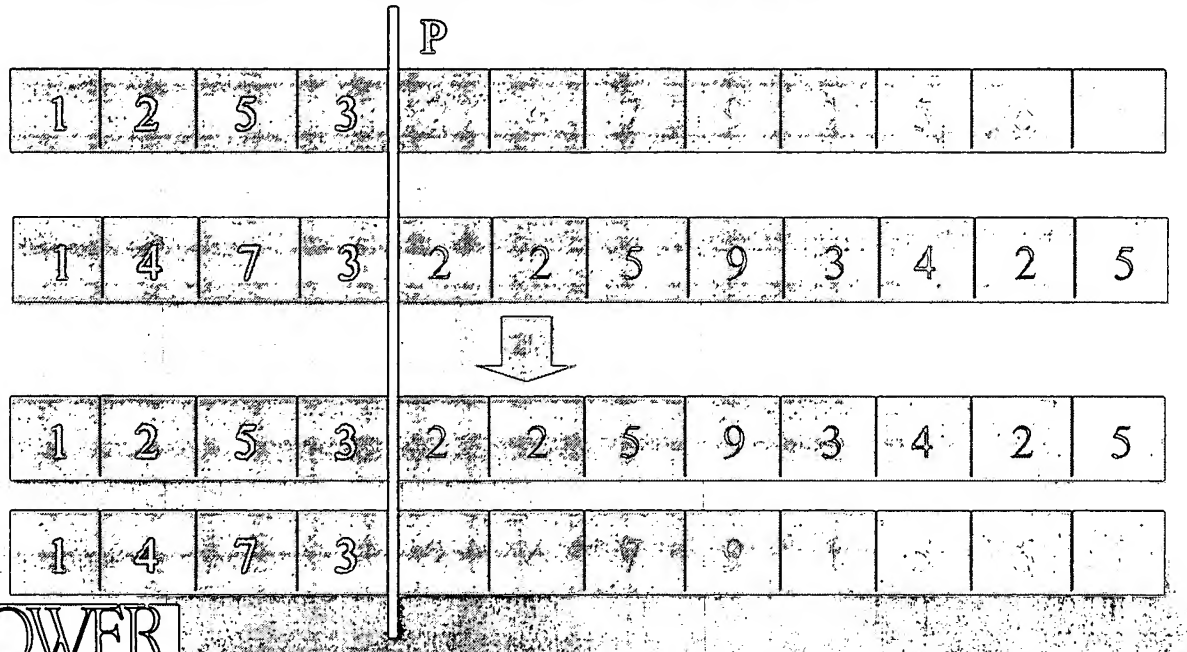
Genetic Operators

- Block Move
  - Randomly selects two positions p_1 and p_2 in a genome
  - switch two blocks starting at p_1 and p_2 with length of N_b



Genetic Operators

- Crossover
  - Randomly selects 2 genomes based on their fitness
  - Randomly selects a position in a genome and crossover the 2 genomes to form two new genomes



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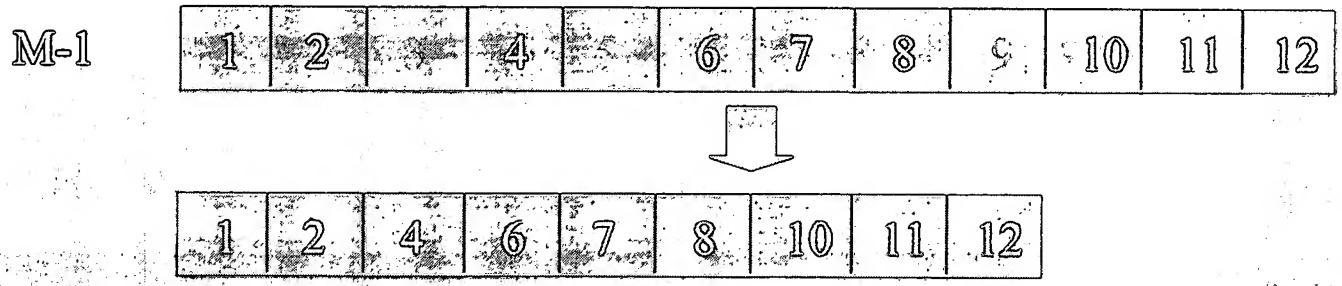
Constraints

- Shipping
  - No shipment from a marshalling yard to certain auction sites (Hard Constraints)
  - The number of vehicles to be shipped is preferred to be in the multiple of N_t (Soft Constraint)
  - Certain percentage of vehicles from a marshalling yard preferred to be shipped to certain auction sites (Soft Constraint)
- Site
  - The number of vehicles of a specific model and model year preferred to keep below N_s (Hard Constraint)

Handling Hard Constraints

- Decoder/Constraint Programming (Mutation)
  - Create an array to hold all the feasible auction sites for a marshalling yard
  - The new auction site generated in a genetic operator comes only from these feasible auction sites
  - A Genome gives instruction on how to create feasible solutions



Gene Repair and Replacement

- Repair on the spot (Switch, Block Move, and Cross Over)
  - When the newly generated genome violates the hard constraint, new feasible auction sites will be randomly generated to replace the invalid ones
- Replacement Strategies
  - Greedy (replace the weakest individual), or
  - Probabilistic selection proportional to fitness

Initial Conditions

- Random
  - Randomly generated assignments of auction locations for all vehicles
- User Defined
  - A complete or partial auction location assignment provided by user for all vehicles
- Mixed
  - User defined initial conditions mixed with random variations

Fitness Function

Fitness :
$$F = f_{shipping} \times f_{site} \times P^A$$

Assignment :
$$A = \{< v, a >\}$$

Profit :
$$P^A = \sum_{v=1}^{N} P_v^a = \sum_{v=1}^{N} (p_v^a - \Delta p_v^a - S_v^a - T_v^a)$$

Revenue :
$$\sum_{v=1}^{N} (p_v^a - \Delta p_v^a) = \begin{cases} \sum_{a=1}^{A} \sum_{mdl=1}^{MDL} N_{mdl}^a \times p_{mdl}^a & \text{if } N_{mdl}^a \le N_{threshold} \\ \sum_{a=1}^{A} \sum_{mdl=1}^{MDL} N_{mdl}^a \times (p_{mdl}^a - N_{mdl}^a \times e_{mdl}^a) & \text{if } N_{mdl}^a > N_{threshold} \end{cases}$$

Shipping Cost :
$$\sum_{v=1}^{N} S_v^a = \sum_{m=1}^{M} \sum_{a=1}^{A} (N_{m \to a} + N_{unused,m \to a}) \times c_{shipping,m \to a}$$

Time Cost :
$$\sum_{v=1}^{N} T_v^a = \sum_{mdl=1}^{MDL} \sum_{m=1}^{M} \sum_{a=1}^{M} N_{mdl,m \to a} \times t_{shipping,m \to a} \times (c_{dep,mdl} + c_{ir,mdl})$$

Shipping Constraint Factor :
$$f_{shipping} = \prod_{i=1}^{V} f_{shipping,i} = \prod_{i=1}^{V} (1.0 - shipping\_violation\ \%)_i$$

Site Constraint Factor :
$$f_{site} = \prod_{i=1}^{V} f_{site,i} = \prod_{i=1}^{V} (1.0 - site\_violation\ \%)_i$$

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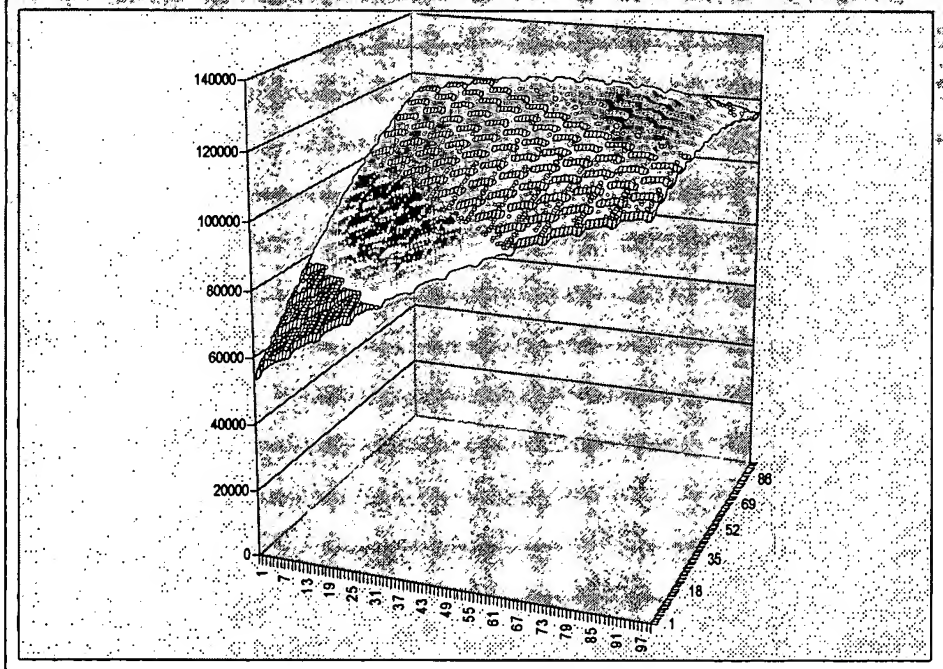
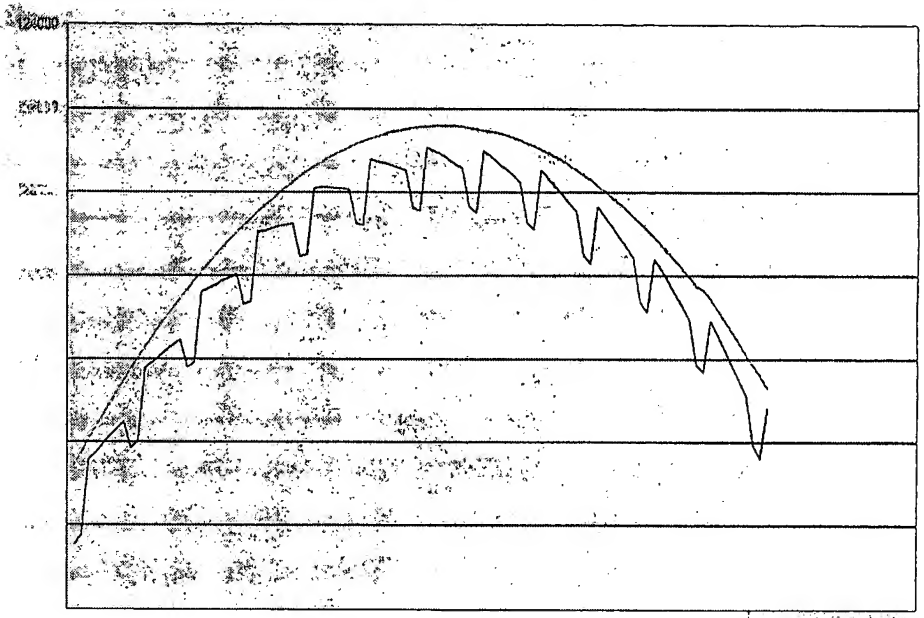
Profit Surface





- Two stage optimization: 1) Global search without shipping penalty; 2) Turn on shipping penalty when global optimal search converges

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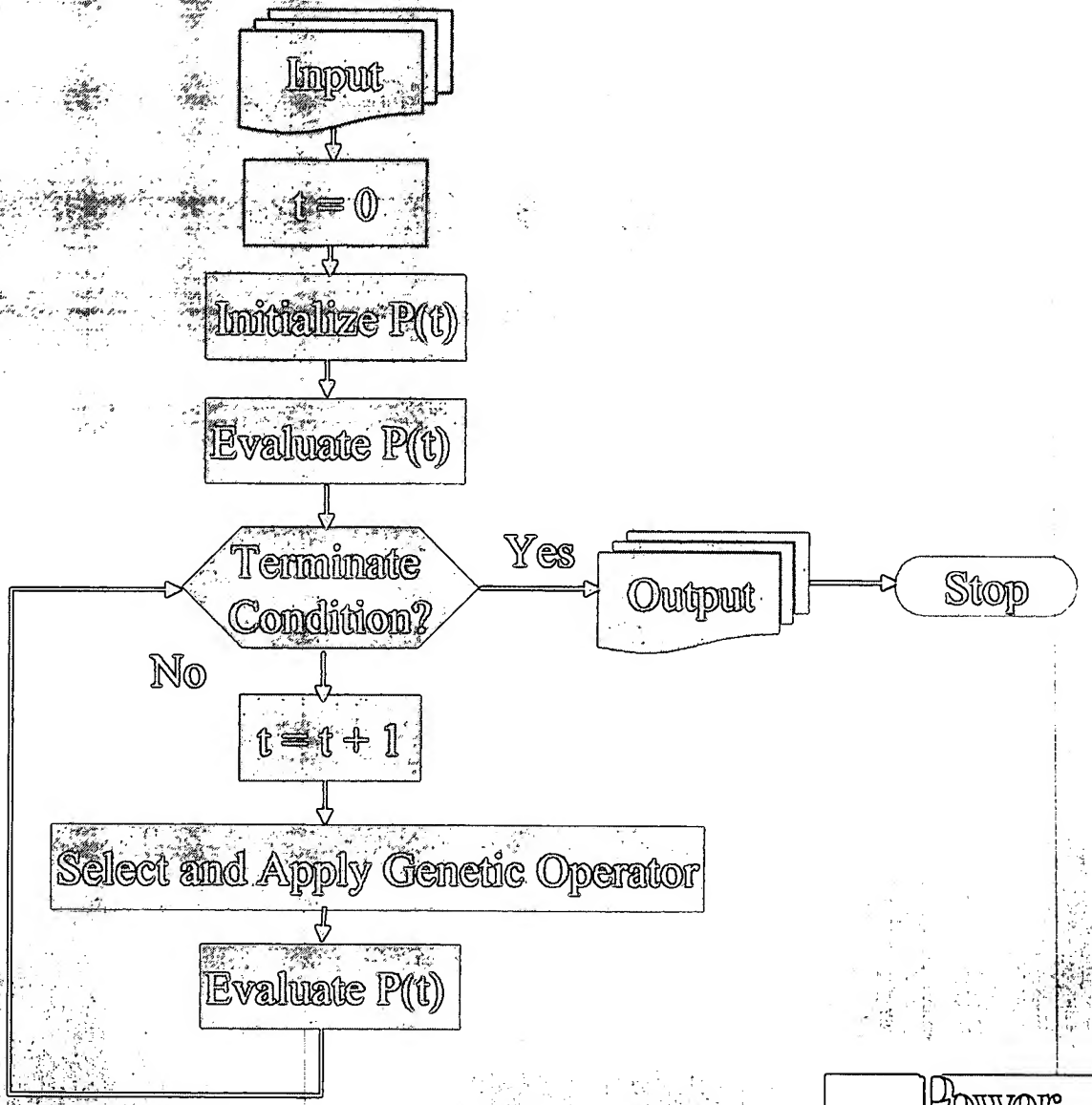
Parameters

- Population size: N
- Operator selection probabilities: p_s, p_m, p_w, p_b, and p_c
- Operator parameters
  - Mutation: Selected gene number N_m
  - Switch: Selected gene number N_s
  - Block move: block length L
- Convergence: Criteria, and converge generation number I
- Flags: Initial condition and replacement method

ODAV System Structure



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Pilot Study for an Automotive Manufacturer

- 27 Marshalling yards and 29 auction sites
- 1260 vehicles of 70 models/nameplates
- 1 model year
- Auction prices, shipping cost, shipping time, interest cost, and depreciation rates provided by the Manufacturer
- Assume volume elasticity \$5/vehicle with $N_{threshold} = 10$
- Assume 8 vehicles per trailer
- Population Size: 5
- Convergence criteria:

  $|f(t+1)-f(t)| < \$200$ for 10,000 consecutive generations

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Original Auction Vehicle Distribution Plan

	500	501	503	506	508	509	529	530	532	533	535	537	538	539	540	550	553	554	556	557	558	561	586	590	593	594	595	597	598
VR101		33	8	5				25														2							
VR104					13			7				8				1		2				5							
VR107												1						23				1				112		82	
VR108							1						13					3	11	1			38			24			
VR110									1																				
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VR123																			6										
VR124		8										17	6						27	153									
VR125													1											50					
VR126																										23			
VR130				93																									
VR131																													
VR132													10																
VR133																						4							
VR134																	54												
VR135	5																												
VR136						13																							

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Optimized Auction Vehicle Distribution Plan

	500	501	503	506	508	509	529	530	532	533	535	537	538	539	540	550	553	554	556	557	558	561	586	590	593	594	595	597	598
VR101	42	4	8	31	22	5						1					1	4	1			2							
VR104		2	1	2	4		2		2			23																	
VR107		3	32		3												2		11			3	40		79		2	44	2
VR108		3	6		2						2				5		1	3				4	58				3		4
VR110													1																
VR112					3					8			3					1				3							
VR113	3				16	7	1										1	2		24		5							
VR114		2																	1			7	1				1		30
VR115																									21		1		1
VR116										6								3									8		
VR117		3	22	13	21																								
VR118			8		6	1	1																						
VR119			1		16			4			1								3										
VR120																													
VR121			3		3												1		1										
VR122																		52											
VR123				1															2	3									
VR124	6	1			32					1			1				13	7	56	70		24							
VR125		1																					5	1	16		21		7
VR126																	8	1								9	5		
VR130	11	11	2	28	29												4	8											
VR131																													
VR132					1								4							5									
VR133																						4							
VR134																	54												
VR135	4		1																										
VR136	7					5																1							

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Optimal vs. Original Distribution Plans

	Original ($)	Optimal ($)	Change ($)
Profit	19,291,821	19,599,321	307,500
Auction Revenue	19,557,169	20,145,360	588,191
Shipping Cost	(131,947)	(381,808)	(249,861)
Time Value Cost	(25,158)	(35,314)	(10,156)
Volume Elasticity Cost	(59,230)	(53,770)	5,460
Shipping Waste Cost	(49,013)	(75,147)	(26,134)

- Simulation Time: ~3 min. on Sony PCG-FXA36 Laptop

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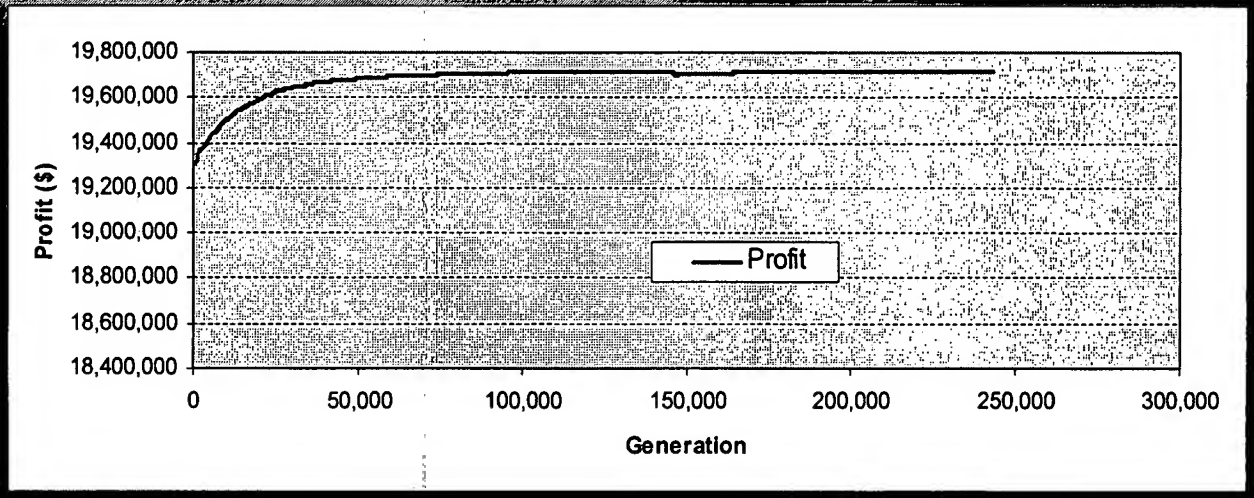
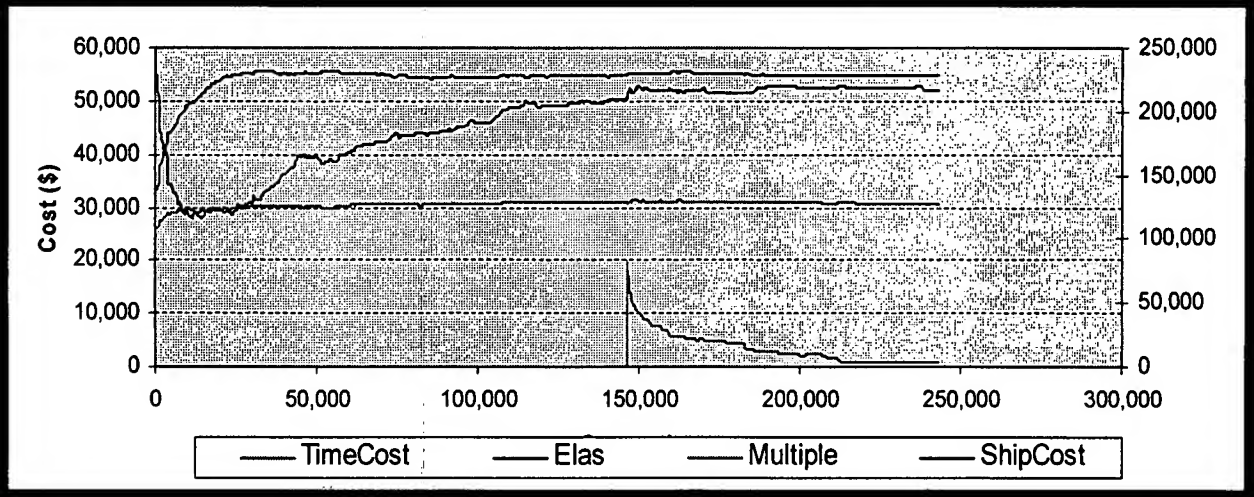
Optimization Solution Process Trace





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Summary

- The optimal distribution of auction vehicles can be solved successfully by Evolutionary Algorithm
- Two stage optimization not only avoids being trapped in local optima, but also increase the efficiency of the optimization
- Decoder can efficiently and accurately handle the shipping hard constraints
- Fine tuning the system is still going on
- The effects of individual operators need further study
- Paretal optimization

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A Proposal on the Second Pilot Study for the Optimal Distribution of DCX Auction Vehicles

Presented to DCX Remarketing

January 11, 2002

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Summary of the 1st Pilot Study

- Tested ODAV on one week of auction vehicles (~1300 vehicles with 29 marshalling yards and 43 auction sites)
- Results indicated that there is an opportunity to improve DCX's remarketing profit by ~$300 per vehicle, amounting to $60 million a year for 200,000 vehicles
- The pilot test was based on DCX's floor prices by vehicle by auction site
- Tested effects of constraints on number of shipping units
- Made assumptions on local demand elasticity, depreciation costs, inventory interest charge, and certain shipping costs

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Proposal on the Second Pilot Test (for discussion)

- Objective
  - Evaluate the ability of ODAV to increase DCX remarketing profits by applying ODAV to real auction determination tasks
- ODAV Pilot Testing Task Scope
  - Five marshalling yards
  - Five vehicle model/model year combinations
  - Testing time period length of 4-6 weeks
  - Using JDPA's auction value predictions for the inputs to the optimization system

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Proposal on the Second Pilot Test (for discussion)

- Result Evaluation
  - Metric: Average remarketing profit per unit =
    - Sum of (gross auction prices - shipping costs - interest charges - "quality" adjustment for each unit divided by the total number of units
    - "Quality" adjustments are to equalize vehicles on their mileage, conditions, equipment levels, and open/closed auctions
  - Evaluation Method:
    - Perform another optimization after the test period using estimated price information based on actual auction results
    - Compare the optimization result after the fact against the actual performance using the above metric
    - Attribute the differences to re-distribution, errors in predicted prices, elasticity costs, and inventory charges, if any

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Challenges

- The main challenge to this and future applications of ODAV is the requirement for a good accuracy in
  - Auction value prediction
  - Local demand elasticity estimation
  - Shipping costs and days estimation
  - local inventory level
- Other possible challenges include
  - Unexpected volatility in local market conditions
  - Interactions between auction vehicles distributed by ODAV and those distributed with the current DCX remarketing system
  - Hidden constraints/assumptions in current shipping processes

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Suggested Marshalling Yards

Myard	State	VehNum
VR107	CA	221
VR124	MO	211
VR101	NY	121
VR130	MA	93
VR108	CA	91
VR113	NC	59
VR117	NY	59
VR134	MI	54
VR122	MN	52
VR125	NV	51
VR114	AZ	42
VR104	FL	36
VR119	TN	25
VR115	OR	23
VR126	MT	23
VR112	TX	18
VR116	CO	17
VR118	PA	16
VR136	VA	13
VR132	LA	10
VR121	IL	9
VR123	MO	6
VR135	PA	5
VR133	IN	4
VR110	GA	1

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Suggested Vehicle Models/ModYears

MY	Model	VehNum
2001	INTREPID	193
2001	NEON HI-LINE	184
2001	GD CARAVAN SPORT	174
2001	GD CHER 4WD	113
2001	STRATUS 4DR	99

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Suggested Steps

- Agree on project scope, approach, evaluation method, and selection of vehicle models and marshalling yards
- Gather historical auction data with vehicle details for the selected models (include all auction sites)
- Agree on estimates for local demand elasticity, inventory interest charge, weekly depreciation rate, shipping costs and days
- DCX provides JDPA with auction vehicle VIN and detailed features
- JDPA predicts auction prices for all vehicles at every auction site
- JDPA provides optimal vehicle shipping plan to DCX
- Repeat the last three steps for 4-6 weeks followed by performance evaluations

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Project Deliverables and Fees

- Deliverables
  - Price predictions for vehicles and for every possible auction
  - Auction distribution plans for each of the five weeks
  - Performance evaluation and study reports
- Fees
  - $100,000 for the proposed scope and deliverables
  - 80% of the fees can be credited towards the future purchase of the ODAV system

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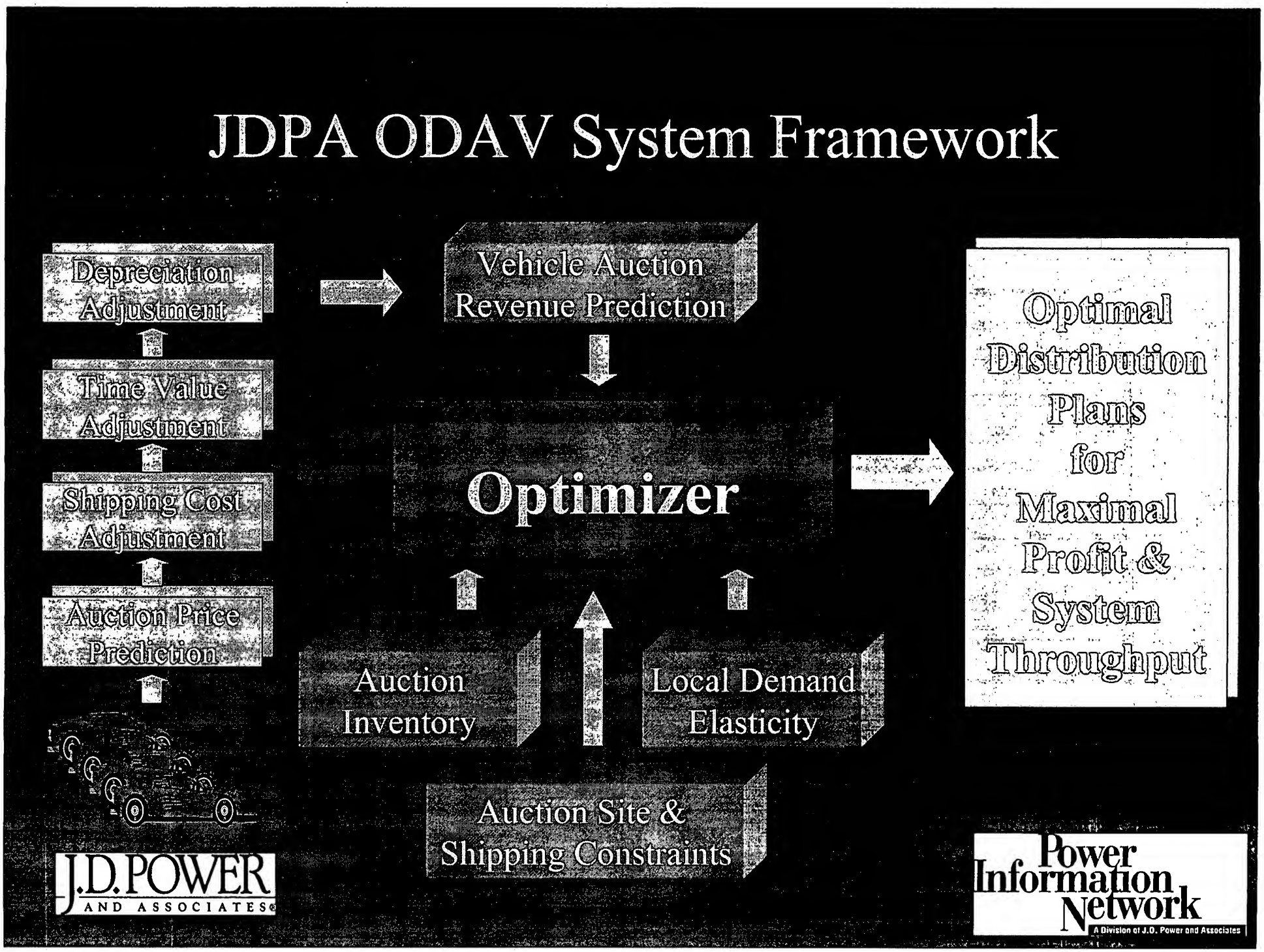
JDPA ODAV System Framework



Auction Price Prediction

- Predict the most likely gross auction proceeds for each individual vehicle at each alternative auction site

	Site #1	Site #2	Site #3	...	...	...	Site #N
Veh #1	$10,900	$11,273.23	$9,734.41	...	...	...	$10,972.74
Veh #2	$10,805	$9,875.20	$8,077.39	...	...	...	$10,828.60
Veh #3	$9,827	$10,679.54	$6,485.12	...	...	...	$13,485.32
Veh #4	$12,368	$15,196.39	$16,097.55	...	...	...	$8,836.70
Veh #5	$13,521	$15,334.79	$15,268.98	...	...	...	$11,649.50
Veh #6	$7,342	$4,860.51	$6,203.87	...	...	...	$5,858.03
Veh #7	$2,050	$1,754.86	$2,419.00	...	...	...	$2,019.07
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Veh #M	$9,809	$13,446.37	$9,791.94	...	...	...	$11,116.10

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Shipping Cost Adjustment

- Deduct shipping cost from the gross auction proceeds of each individual auction vehicle
- Shipping cost amount depends on the originating Marshalling Yard and the auction site destination

	Site #1	Site #2	Site #3	...	...	...	Site #N
M. Yard #1	$150	$150.00	$250.00	...	...	...	$150.00
M. Yard #2	$150	$150.00	$500.00	...	...	...	$200.00
M. Yard #3	$200	$200.00	$250.00	...	...	...	$150.00
M. Yard #4	$250	$200.00	$250.00	...	...	...	$200.00
M. Yard #5	$150	$100.00	$50.00	...	...	...	$250.00
M. Yard #6	$150	$150.00	$100.00	...	...	...	$250.00
M. Yard #7	$100	$100.00	$150.00	...	...	...	$150.00
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
M. Yard#M	$200	$150.00	$200.00	...	...	...	$150.00

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Time Value Adjustment

- Deduct estimated value lost due to interest cost for the time spent in vehicle shipping

	Site #1	Site #2	Site #3	...	...	...	Site #N
M. Yard #1	10	5	5				4
M. Yard #2	10	20	15				3
M. Yard #3	14	25	15				3
M. Yard #4	3	5	20				10
M. Yard #5	5	10	20				10
M. Yard #6	10	15	10				12
M. Yard #7	10	10	15				3
...							
...							
...							
M. Yard #M	15	20	10				4

Shipping Time Table (Days)

	Interest Costs Per Day
Vehicle Model #1	$5.00
Vehicle Model #2	$15.00
Vehicle Model #3	$7.00
Vehicle Model #4	$10.00
Vehicle Model #5	$10.00
Vehicle Model #6	$12.00
Vehicle Model #7	$10.00
...	
...	
...	
Vehicle Model #M	$8.00

Time Value Table

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Vehicle Depreciation Adjustment

- Vehicle depreciation rate is a function of vehicle age as well as seasons in a year
- Timing of auctions needs to consider trade-off between resale value gains and possible depreciation losses

	Weekly Depreciation Rate
Vehicle Model #1	$300
Vehicle Model #2	$500
Vehicle Model #3	$200
…	…
…	…
…	…
Vehicle Model #K	$350

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Auction Inventory

- Levels of auction inventory can have an effect on gross auction proceeds and are constrained by auction site capacity

	Site #1	Site #2	Site #3	...	...	...	Site #N
Veh Model #1	53	23	67	...	...	...	91
Veh Model #2	68	18	62	...	...	...	2
Veh Model #3	72	74	56	...	...	...	40
Veh Model #4	6	75	38	...	...	...	79
Veh Model #5	31	16	18	...	...	...	64
Veh Model #6	86	84	78	...	...	...	27
Veh Model #7	53	82	49	...	...	...	58
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Veh Model #K	67	77	88	...	...	...	40

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Auction Site Capacity Constraints

- For each auction site, there are both a limit on the number of vehicles of a particular type and a limit on the total number of vehicles

	Site #1	Site #2	Site #3	...	...	...	Site #N
Vehicle Model #1	100	200	50	...	...	...	100
Vehicle Model #2	100	250	100	...	...	...	100
Vehicle Model #3	100	100	100	...	...	...	150
Vehicle Model #4	50	100	75	...	...	...	200
Vehicle Model #5	100	50	100	...	...	...	150
Vehicle Model #6	300	100	150	...	...	...	50
Vehicle Model #7	100	100	100	...	...	...	100
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Vehicle Model #M	200	60	100	...	...	...	50
Total	500	650	400	...	...	...	350

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Local Demand Elasticity

- Local demand elasticity refers to the sensitivity of auction prices in response to volume fluctuations

	Site #1	Site #2	Site #3	...	...	...	Site #N
Vehicle Model #1	-$0.20	-$0.20	-$0.10	...	...	...	-$0.20
Vehicle Model #2	-$0.10	-$0.20	-$0.15	...	...	...	-$0.10
Vehicle Model #3	-$0.10	-$0.15	-$0.15	...	...	...	-$0.20
Vehicle Model #4	-$0.15	-$0.20	-$0.10	...	...	...	-$0.15
Vehicle Model #5	-$0.20	-$0.20	-$0.10	...	...	...	-$0.10
Vehicle Model #6	-$0.20	-$0.15	-$0.15	...	...	...	-$0.20
Vehicle Model #7	-$0.15	-$0.10	-$0.20	...	...	...	-$0.15
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...
Vehicle Model #M	-$0.20	-$0.10	-$0.30	...	...	...	-$0.10

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System Output: Optimal Distribution Plans

- Solutions are ranked by net proceeds (= estimated gross auction proceeds - shipping costs - time_value_lost - depreciation) *

	Site	Gross Proceeds	Shipping Cost	Time-Cost	Net Proceeds	Est. Auc. Date
Vehicle #1	1	$12,450.00	$250.00	$100.00	$12,100.00	07/30/01
Vehicle #2	2	$8,000.00	$100.00	$10.00	$7,890.00	07/30/01
Vehicle #3	1	$9,570.00	$150.00	$10.00	$9,410.00	08/07/01
Vehicle #4	4	$11,590.00	$220.00	$50.00	$11,320.00	08/07/01
Vehicle #5	20	$3,925.00	$140.00	$10.00	$3,775.00	08/09/01
Vehicle #6	2	$4,750.00	$100.00	$100.00	$4,550.00	08/02/01
Vehicle #7	3	$12,120.00	$100.00	$50.00	$11,970.00	08/02/01
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
Vehicle #M	41	$13,120.00	$100.00	$100.00	$12,920.00	08/02/01

* Auction related costs are excluded here

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